CHAPTER 6

Corneal and Refractive Surgery

Keratoplasty

Keratoplasty (corneal transplantation, grafting) is an operation in which abnormal corneal host tissue is replaced by healthy donor cornea. A corneal graft may be (a) *full-thickness (penetrating)* or (b) *partial-thickness (lamellar or deep lamellar)*.

Penetrating keratoplasty

Indications

1. **Optical** keratoplasty is most often performed to improve vision. Important indications include pseudophakic bullous keratopathy, keratoconus, dystrophies, degenerations and scarring.
2. **Tectonic** grafting may be carried out to restore or preserve corneal integrity in eyes with severe structural changes such as stromal thinning and descemetoceles.
3. **Therapeutic** transplantation may afford removal of infected corneal tissue in eyes unresponsive to anti-microbial therapy.
4. **Cosmetic** grafting may rarely be performed to improve the appearance of the eye.

Donor tissue

Donor tissue should be removed within 24 hours of death. Corneas from infants are usually not used, being floppy and likely to result in high astigmatism. Corneas from donors over the age of 70 years may also be inappropriate due to low endothelial cell counts. Preoperative evaluation of donor tissue includes slit-lamp examination and, ideally, specular microscopy. Corneas should not be utilized under the following circumstances:

- Death of unknown cause.
- Infectious diseases of the CNS (e.g. Creutzfeldt–Jakob disease, systemic sclerosing panencephalitis, progressive multifocal leucoencephalopathy).
- Certain systemic infections (e.g. AIDS, viral hepatitis, syphilis, septicaemia).
- Leukaemia and disseminated lymphoma.
- Intrinsic eye disease (e.g. malignancy, active inflammation) or previous intraocular surgery.

Prognostic factors

The following factors may adversely affect the prognosis of a corneal graft and should therefore be addressed prior to surgery:

- Abnormalities of the eyelids such as blepharitis, trichiasis, ectropion and entropion. They should be corrected before surgery.
- Tear film dysfunction.
- Recurrent or progressive forms of conjunctival inflammation, such as atopic conjunctivitis and ocular cicatricial pemphigoid.
- Severe stromal vascularization, absence of corneal sensation, extreme thinning at the proposed host–graft junction and active corneal inflammation.
- Anterior synechiae.
- Uncontrolled glaucoma.
- Uveitis.

NB: In general, the most favourable cases are localized scars, keratoconus and dystrophies.

Surgical technique

1. **Determination of graft size** is done preoperatively with a variable slit beam and operatively by trial placement of trephines with different diameters. Grafts of diameter 8.5 mm or more are prone to postoperative anterior synechiae formation, vascularization and increased intraocular pressure. An ideal size is 7.5 mm; grafts smaller than this may give rise to high astigmatism.
2. **Excision of donor cornea** should always precede that of host cornea. Donor tissue is prepared by trephining a previously excised corneoscleral button, endothelial side up in a concave Teflon block. Alternatively, the donor may be trephined from the intact donor globe having first injected air or viscoelastic substance into the anterior chamber. The donor button is usually about 0.25 mm larger in diameter than the planned diameter of the host opening, to facilitate watertight closure, minimize postoperative flattening and reduce the possibility of postoperative glaucoma.
3. **Excision of diseased host tissue** is then carried out taking care not to damage the iris and lens with the trephine.

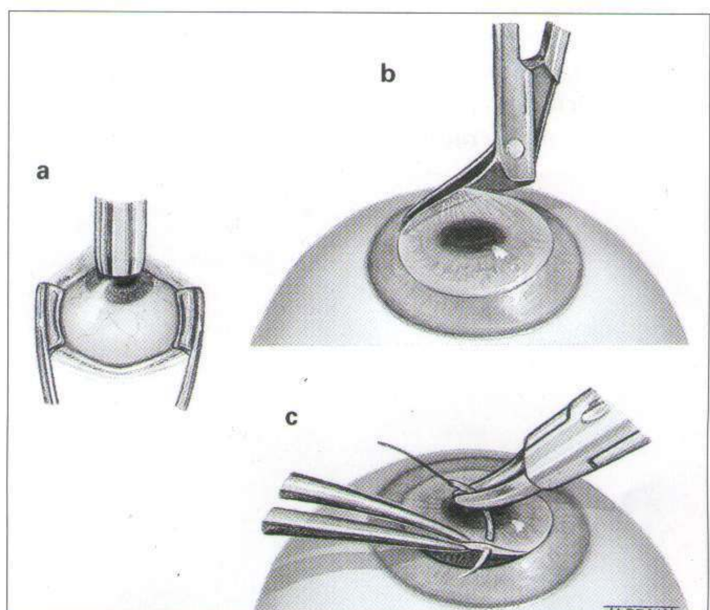


Fig. 6.1
Technique of penetrating keratoplasty. **(a)** Trephination of host cornea; **(b)** completion with scissors; **(c)** suturing of donor button

a. The lens can be protected to some extent by achieving preoperative miosis with topical pilocarpine and employment of a viscoelastic substance during surgery.
b. Recipient cornea may be excised with a manual (Fig. 6.1a), motorized or vacuum trephine. The latter adheres to recipient cornea and reduces slippage. Rapid decompression of the eye, with its attendant risks of prolapse of intraocular contents and expulsive suprachoroidal haemorrhage, can be avoided by performing a partial-thickness trephination and then entering the anterior chamber with a diamond knife.
c. Excision can then be completed with knife or scissors (Fig. 6.1b).

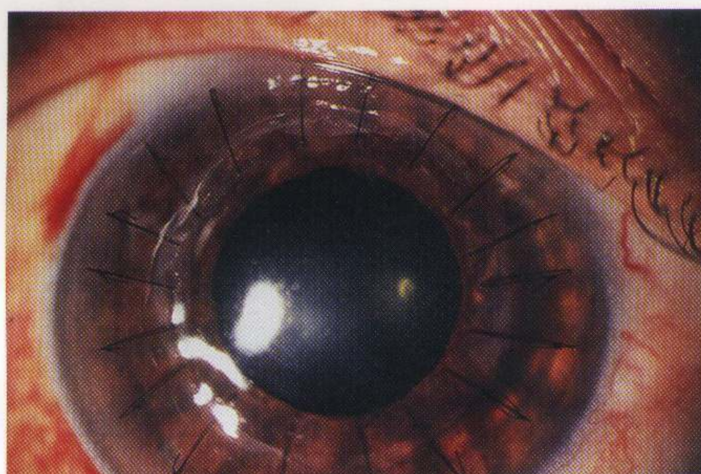
4. **Fixation of donor tissue** is usually with 10-0 monofilament nylon. The corneal 'bites' are almost full-thickness (Fig. 6.1c) to ensure that Descemet membrane is apposed and posterior wound gape avoided.
   a. Four interrupted cardinal sutures are initially placed.
   b. Closure is then completed with interrupted sutures (Fig. 6.2), continuous running sutures (Fig. 6.3), or a combination of both.
5. **Replacement** of viscoelastic substance with balanced salt solution.

Postoperative management

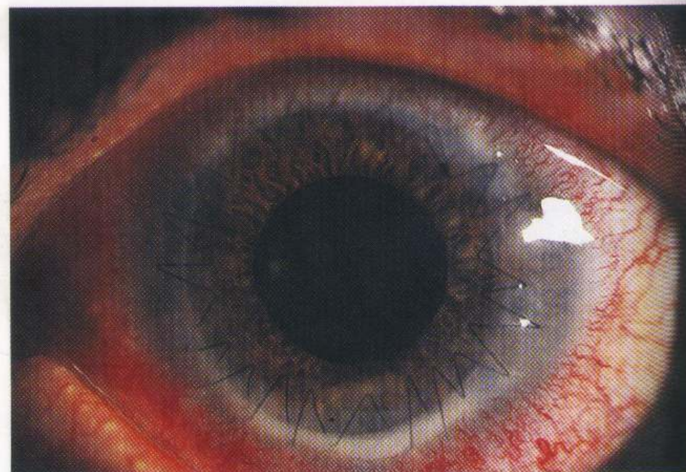
1. **Topical**
   a. Steroids are used to reduce the risk of immunological graft rejection. After initial administration q.i.d. for a few weeks, the dose may be tapered, depending on the condition of the eye. Steroids are, however, usually continued at low doses such as once daily for a year or more.

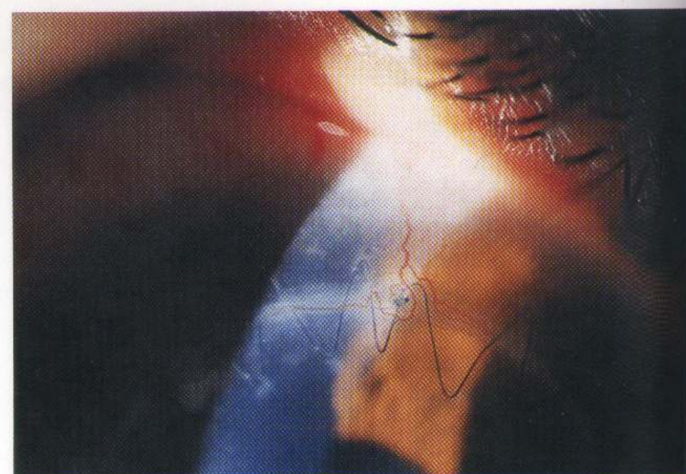
> *NB:* Unpreserved drops should be used until the graft has epithelialized.

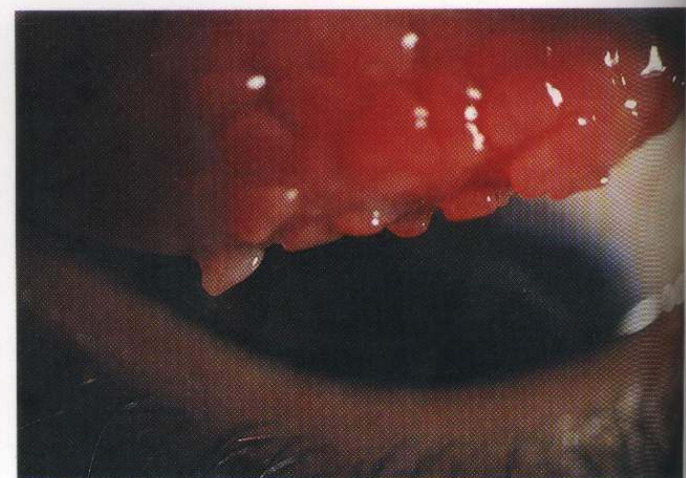
   b. Mydriatics b.d. for 2 weeks, or longer if uveitis persists.
2. **Oral** aciclovir, may be used in the context of pre-existing herpes simplex keratitis to minimize the risk of recurrence.


Fig. 6.2
Interrupted sutures

3. **Removal of sutures** when the graft–host junction has healed. This is usually after 9–12 months, although in elderly patients it may take much longer.


Fig. 6.3
Continuous suture


Fig. 6.4
Protruding suture


Fig. 6.5
Papillary hypertrophy due to irritation by a protruding suture

4. **Rigid contact lenses** may be required to optimize visual acuity in eyes with astigmatism but not until all sutures have been removed.

Postoperative complications

1. **Early** complications include persistent epithelial defects, irritation by protruding sutures (Fig. 6.4) which may give rise to papillary hypertrophy (Fig. 6.5), wound leak, flat anterior chamber, iris prolapse, uveitis, elevated intraocular pressure and infection.
2. **Late** complications include astigmatism, recurrence of initial disease process on the graft, late wound separation, retrocorneal membrane formation, glaucoma and cystoid macular oedema.

Graft failure

1. **Early** failure is characterized by cloudiness of the graft from the first postoperative day (Fig. 6.6). It is caused by endothelial dysfunction resulting from defective donor endothelium or operative trauma.
2. **Late** failure is usually due to immunological graft rejection. About 50% of cases occur within the first 6 postoperative months, and the vast majority within 1 year. Rejection may affect either the epithelium or endothelium.
   a. ***Epithelial*** rejection is characterized by a linear epithelial opacity (Fig. 6.7) which may be relatively asymptomatic and of little long-term consequence. This is followed by the appearance of multiple small subepithelial infiltrates, reminiscent of adenoviral keratitis (Krachmer spots) (Fig. 6.8), which may be associated with mild iritis. Intensive topical steroids are usually effective in reversing this phenomenon.
   b. ***Endothelial*** rejection is very much more serious, since endothelial cells destroyed by the immunological attack cannot regenerate. Permanent corneal oedema may therefore result. Initially, endothelial rejection is characterized by iritis and inflammation at the graft–host junction (Fig. 6.9). This is followed by the

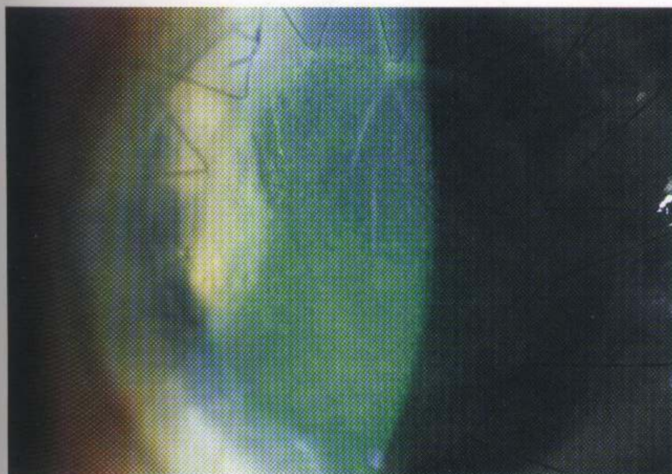


Fig. 6.6
Cloudy graft due to early endothelial failure

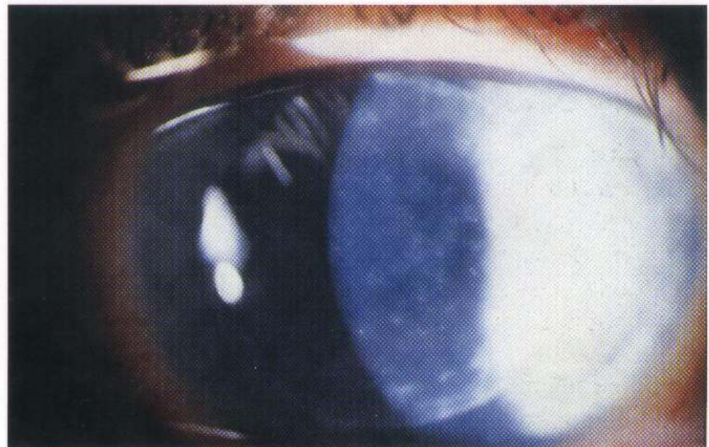


Fig. 6.8
Multiple small subepithelial infiltrates associated with late epithelial rejection (Courtesy of D. Easty)



Fig. 6.7
Linear epithelial opacity associated with late epithelial rejection (Courtesy of D. Easty)

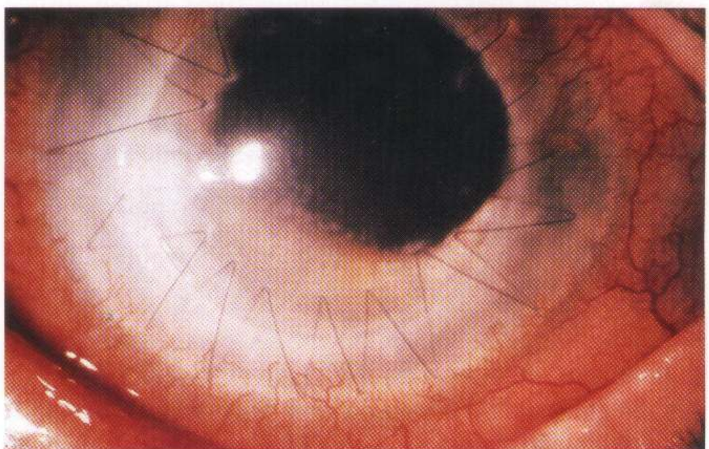


Fig. 6.9
Keratic precipitates and inflammation at the graft–host junction associated with early endothelial rejection (Courtesy of D. Easty)

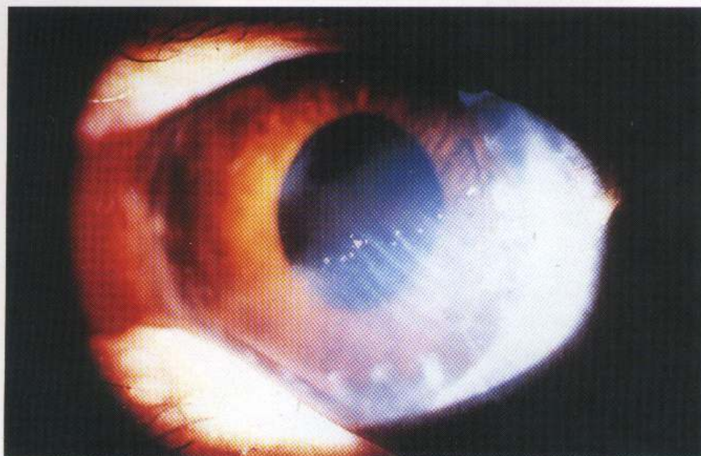


Fig. 6.10
Linear endothelial precipitates (Khodadoust line) and corneal oedema associated with severe endothelial rejection (Courtesy of D. Easty)

development of a linear arrangement of endothelial precipitates (Khodadoust line) and corneal oedema (Fig. 6.10). Treatment involves intensive topical and periocular steroids. Occasionally systemic immunosuppression may be necessary.

Lamellar keratoplasty

Lamellar keratoplasty involves partial-thickness excision of the corneal epithelium and stroma so that the endothelium and part of the deep stroma are left behind.

1. **Indications**
   - Opacification of the superficial one-third of the corneal stroma not caused by potentially recurrent disease.
   - Marginal corneal thinning or infiltration as in recurrent pterygium, Terrien marginal degeneration and limbal dermoids or other tumours.
   - Localized thinning or descemetocele formation.
2. **Technique**. This is similar to that of penetrating keratoplasty except that only a partial-thickness area of cornea is grafted.

Deep lamellar keratoplasty

Deep lamellar keratoplasty is a relatively new technique in which all opaque corneal tissue is removed almost to the level of Descemet membrane. The theoretical advantage is the decreased risk of rejection because the endothelium, a major target for rejection, is not transplanted.

1. **Indications**
   - Disease involving the anterior 95% of corneal thickness with a normal endothelium and absence of breaks or scars in Descemet membrane.
   - Chronic inflammatory disease such as atopic keratoconjunctivitis which carries an increased risk of graft rejection.
2. **Advantages**
   - No risk of endothelial rejection although epithelial rejection may occur.
   - Less astigmatism and a structurally stronger globe as compared with penetrating keratoplasty.
   - Increased availability of graft material since endothelial quality is irrelevant.
3. **Disadvantages**
   - Difficult and time-consuming technique with a high risk of perforation in older patients.
   - Interface haze may limit best final visual acuity.
4. **Surgical technique** (developed by R. Melles).
   a. A superior scleral pocket is created similar to that for phacoemulsification and the anterior chamber filled with air.
   b. A lamellar dissection is performed across almost the entire cornea (Fig. 6.11). A zone of total internal reflection in front of the dissector equal to twice the thickness of the underlying stroma is used to judge the depth of the dissection.
   c. The dissection space is expanded with viscoelastic substance (Fig. 6.12).
   d. The superficial corneal lamella is trephined and removed (Fig. 6.13).
   e. Viscoelastic substance is washed away and air released from the anterior chamber.
   f. After removal of the donor endothelium, a full-thickness graft is sutured in place (Fig. 6.14).

NB: The major difficulty lies in judging the depth of the corneal dissection as close as possible to Descemet membrane without perforating.

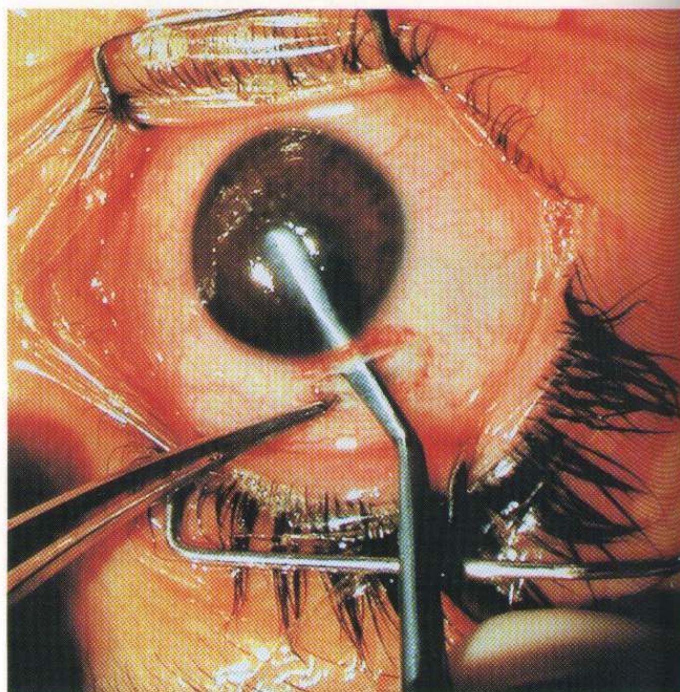


Fig. 6.11
Lamellar dissection in deep lamellar keratoplasty (Courtesy of C. Murphy and T. Wells)

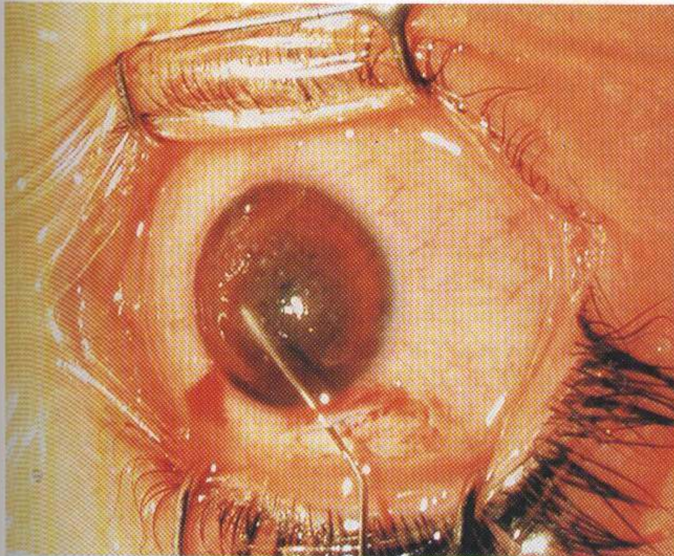


Fig. 6.12
Expansion of dissected space with viscoelastic substance in deep lamellar keratoplasty (Courtesy of C. Murphy and T. Wells)

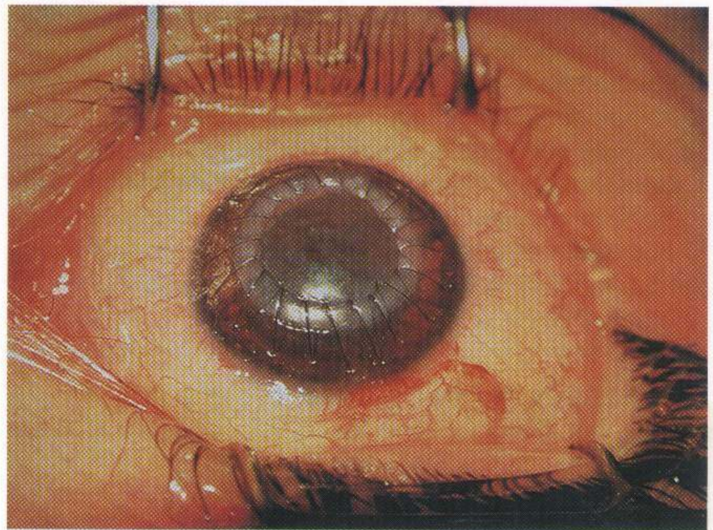


Fig. 6.14
Completed deep lamellar keratoplasty (Courtesy of C. Murphy and T. Wells)

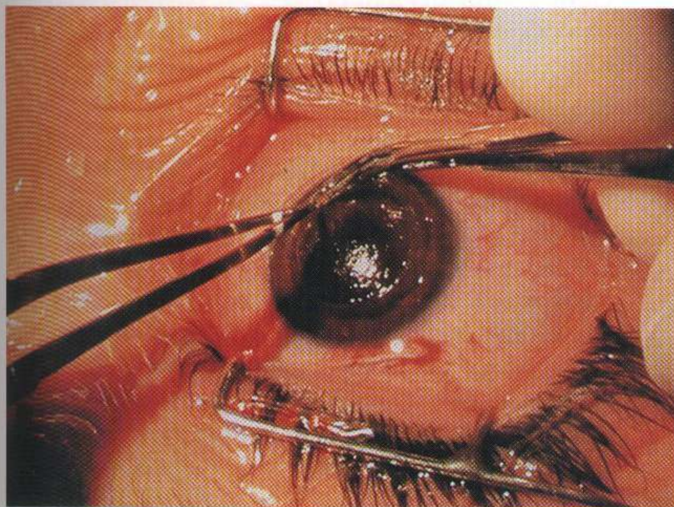


Fig. 6.13
Removal of superficial lamella in deep lamellar keratoplasty (Courtesy of C. Murphy and T. Wells)

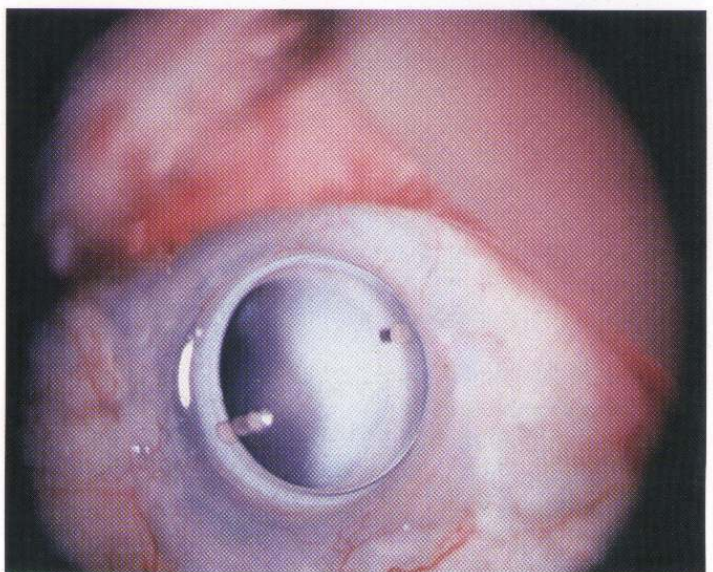


Fig. 6.15
Keratoprosthesis

5. **Postoperative management** is similar to penetrating keratoplasty except that less topical steroids are needed and sutures can be usually removed after 6 months.

Keratoprostheses

Keratoprostheses are artificial corneal implants (Fig. 6.15) used in patients unsuitable for keratoplasty. The modern osteo-odonto-keratoprosthesis consists of the patient's own tooth root and alveolar bone which supports the central optical cylinder. Surgery is difficult and time consuming and is performed in two stages 2–4 months apart.

1. Indications

- Patients with bilateral blindness with visual acuity of hand movements or less but normal optic nerve and retinal function (i.e. accurate light projection, good pupillary responses if obtainable, normal electrophysiological tests and absence of retinal detachment on ultrasonography).
- Severe, debilitating but inactive anterior segment disease with no realistic chance of success from conventional keratoplasty (e.g. Stevens–Johnson syndrome, ocular cicatricial pemphigoid, chemical burns or trachoma).
- Multiple previous failed corneal grafts.
- Normal intraocular pressure with or without medication.

- Absence of active ocular surface inflammation.
- Good patient motivation.

2. **Complications** include glaucoma, retroprosthesis membrane formation, tilting or extrusion of the cylinder and endophthalmitis.
3. **Results**. Approximately 80% of patients experience visual improvement which varies from CF to 6/12 or even better. Poor visual outcome is often associated with pre-existing optic nerve or retinal dysfunction.

Refractive surgery

Introduction

Refractive surgery encompasses a range of procedures aimed at changing the refraction of the eye by altering the cornea and/or crystalline lens, which constitute the principal refracting components. Refractive errors corrected by such procedures include myopia, hypermetropia and astigmatism. The surgical correction of presbyopia is still in its infancy and will not be described.

> ***NB:*** To settle any contact lens-induced corneal distortion, soft contact lenses should be discontinued 2 weeks before keratometry and hard lenses for 1 week for each year of wear.

Correction of myopia

1. **Corneal surgery** is aimed at flattening the cornea.
   a. ***Radial keratotomy*** involves making radial incisions in peripheral cornea (Fig. 6.16). The procedure works reasonably well for low degrees of myopia. However, since the advent of laser procedures its use has diminished.
   b. ***Photorefractive keratectomy*** (PRK — *see* later).
   c. ***Laser in-situ keratomileusis*** (LASIK — *see* later).
   d. ***Intrastromal plastic rings*** which cause central flattening can be used to correct low myopia but are at a very early stage of development. The procedure avoids the visual axis and is potentially reversible.
2. **Lens surgery**
   a. ***Clear lens extraction*** gives very good visual results but carries a small risk of retinal detachment.
   b. ***Phakic posterior chamber intraocular lens implantation*** (implantable contact lenses) may be used for high myopia. The lens is inserted behind the iris, in front of the crystalline lens and supported in the ciliary sulcus. The lens is composed of material derived from collagen with a power of –3 D to –20.50 D. Short-term visual results are promising; however, this procedure should be used with caution because it may be associated with uveitis, endothelial cell loss and cataract formation.
   c. ***Phakic anterior chamber intraocular lens implantation*** with angle support may also be used to correct high myopia. This appears to be well tolerated by the corneal endothelium; apart from pupillary distortion other short-term problems are uncommon.

Correction of hypermetropia

1. **Corneal surgery** aimed at steepening the central cornea is at a much earlier stage than that for myopia.
   a. *PRK* can correct low degrees of hypermetropia.
   b. *LASIK* can correct up to 4 D.
   c. ***Laser thermal keratoplasty*** with a holmium laser can correct low hypermetropia. Laser burns are placed in one or two rings in the corneal periphery (Fig. 6.17). The resultant thermally induced stromal shrinkage is accompanied by increase in central corneal curvature. This change decays over time but the procedure can be repeated.
2. **Lens surgery** involving phakic intraocular lens implantation is at an early stage.

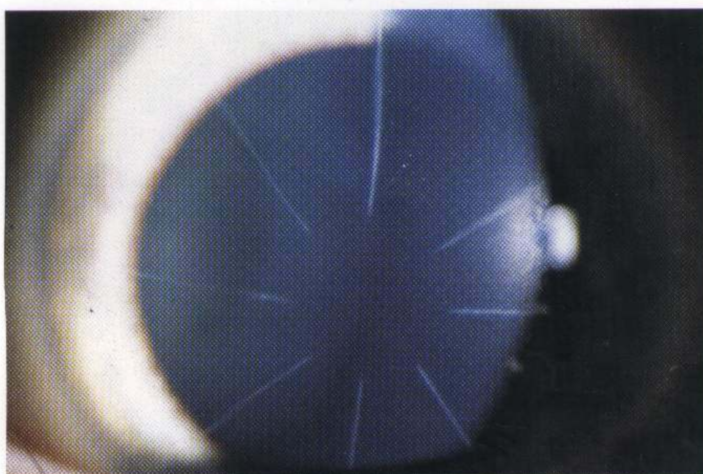


Fig. 6.16
Appearance following radial keratotomy

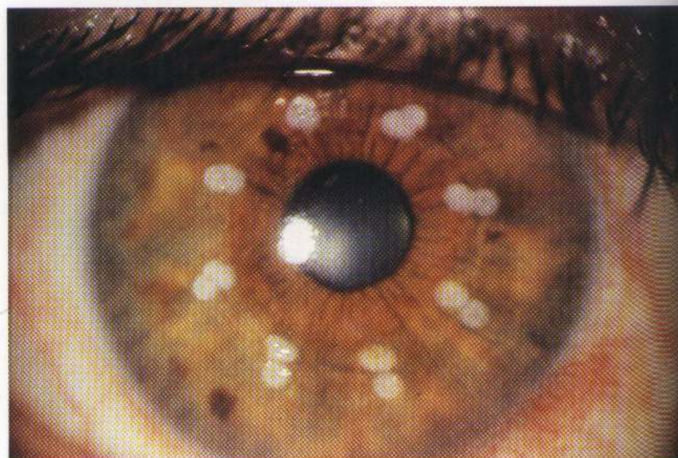


Fig. 6.17
Appearance following laser thermal keratoplasty (Courtesy of H. Nano Jr)

Correction of astigmatism

1. Corneal surgery

a. Arcuate keratotomy involves making paired arcuate incisions on opposite sides of the cornea in the axis of the correcting 'plus' cylinder (the steep meridian). The resultant flattening of the steep meridian coupled with a smaller steepening of the flat meridian at 90° to the incisions reduces astigmatism. The desired result can be controlled by varying the length, depth of the incisions and their distance from the optical centre of the cornea. Arcuate keratotomy may be combined with compression sutures placed in the perpendicular meridian, when treating large degrees of astigmatism such as may occur following penetrating keratoplasty.

b. PRK can correct up to 3 D.

c. LASIK can correct up to 5 D.

2. Lens surgery involves using a toric intraocular implant at the time of cataract extraction. However, postoperative rotation of the implant away from the desired axis may occur.

Photorefractive keratectomy

Photorefractive keratectomy (PRK) is performed with the excimer laser, which can accurately ablate corneal tissue to an exact depth with minimal disruption of surrounding tissue. Myopia is treated by ablating the central anterior corneal surface so that it becomes flatter (Fig. 6.18); approximately 10 μm of ablation corrects 1 D of myopia. Hypermetropia is treated by ablation of the periphery so that the centre becomes steeper. PRK is able to correct myopia up to 6 D, astigmatism up to 3 D and low hypermetropia. Since the advent of LASIK the procedure is being performed less frequently and is largely reserved for patients who are unsuitable for LASIK, such as those with very thin corneas.

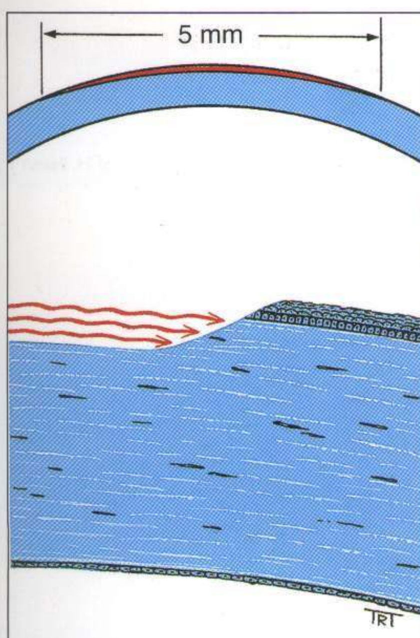


Fig. 6.18
Principles of photorefractive keratectomy for myopia

1. Technique

a. The visual axis is marked and the corneal epithelium removed.

b. The patient fixates on the aiming beam of the laser.

c. The laser is applied to ablate only Bowman layer and anterior stroma (Fig. 6.19). This usually takes 30–60 seconds.

The cornea usually heals within 48–72 hours. A subepithelial haze (Fig. 6.20) invariably develops within 2 weeks and persists for 1–6 months. It rarely causes diminished visual acuity but may produce night glare.

2. Complications include slow-healing epithelial defects, corneal haze and haloes, poor night vision and regression of refractive correction. Uncommon problems include decentred ablations, scarring, abnormal epithelial healing, irregular astigmatism, hypoaesthesia, sterile infiltrates, infection and acute corneal necrosis.



Fig. 6.19
Appearance during photorefractive keratectomy (Courtesy of C. Barry)

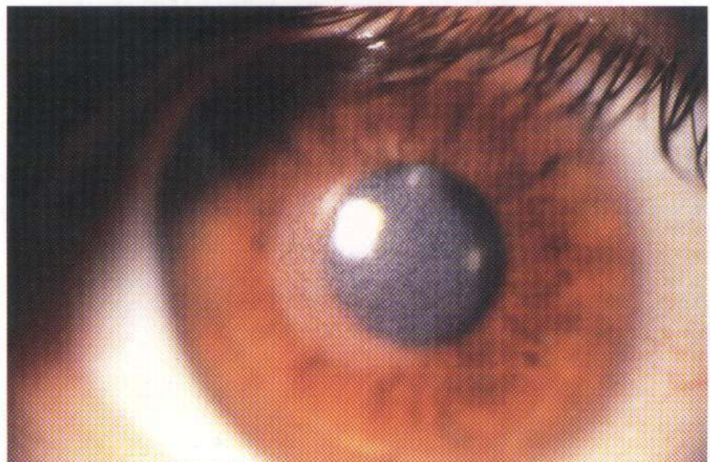


Fig. 6.20
Subepithelial corneal haze following photorefractive keratectomy (Courtesy of H. Nano Jr)

Laser in-situ keratomileusis

Laser in-situ keratomileusis (LASIK) is currently the most frequently performed refractive procedure. It is more versatile than PRK and can correct hypermetropia of up to 4 D, astigmatism of up to 5 D and myopia of up to 12 D depending on corneal thickness. To prevent corneal ectasia, a residual corneal base of 250 μm thickness must remain after the flap has been cut and tissue ablated. The amount of tissue removed and the total treatment is therefore limited by the original corneal thickness (on pachymetry). The thickness of the flap can be varied but thinner flaps are more difficult to handle and are more prone to wrinkling.

1. Technique

a. A suction ring is applied to the globe, which raises the intraocular pressure to over 65 mmHg. This may temporarily occlude the central retinal artery and extinguish vision.

b. The ring is centred on the cornea and provides a guide track into which an automated microkeratome is inserted.

c. The keratome is mechanically advanced across the cornea to create a very thin flap, which is reflected (Fig. 6.21).

d. Suction is released and the bed is treated with the excimer laser as for PRK.

e. The flap is repositioned and allowed to settle undisturbed for 30 seconds.

2. Complications

*a. **Operative flap-related*** complications involving the microkeratome include buttonholes, thin flaps, flap amputation, incomplete or irregular flaps, and rarely corneal perforation.

b. Postoperative

- Wrinkling (Fig. 6.22), distortion or dislocation of the flap.
- Epithelial defects may predispose to epithelial ingrowth under the flap.
- Diffuse lamellar keratitis is characterized by streaky white granular infiltrates confined to the flap interface ('shifting sands of the Sahara') which may resolve spontaneously within a few days or with the use of topical steroids if persistent.
- Other complications include peripheral corneal infiltrates, late infectious keratitis, anterior segment ischaemia and optic neuropathy presumably due to raised intraocular pressure.

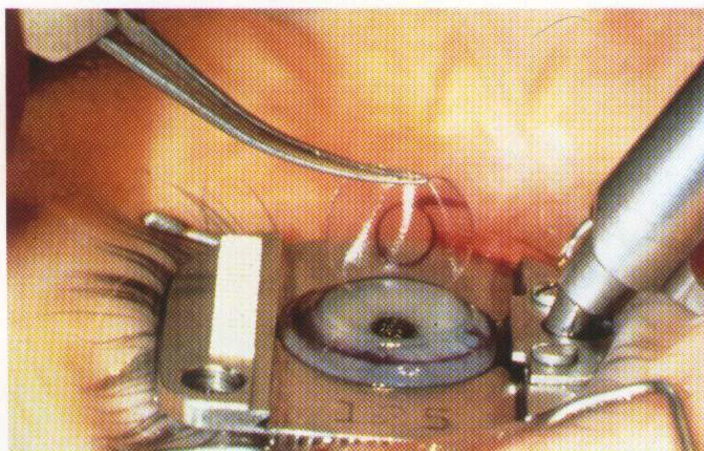


Fig. 6.21
Corneal flap created with a keratome during LASIK (Courtesy of Eye Academy)



Fig. 6.22
Wrinkled flap following LASIK (Courtesy of H. Nano Jr)